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Nakano

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(54) **IMAGE PICKUP DEVICE AND FOCAL PLANE SHUTTER**

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(51) **Int. Cl.**

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G03B 9/42	(2006.01)
H04N 5/238	(2006.01)
H04N 5/376	(2011.01)

(52) **U.S. Cl.**

CPC ***H04N 5/2353*** (2013.01); ***G03B 9/42*** (2013.01); ***H04N 5/238*** (2013.01); ***H04N 5/3765*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

An image pickup device includes: an image pickup element; a control portion sequentially resetting charge stored in the image pickup element for every pixel line in a predetermined direction such that an electronic leading blade moves in a simulated manner; and a focal plane shutter.

6 Claims, 12 Drawing Sheets

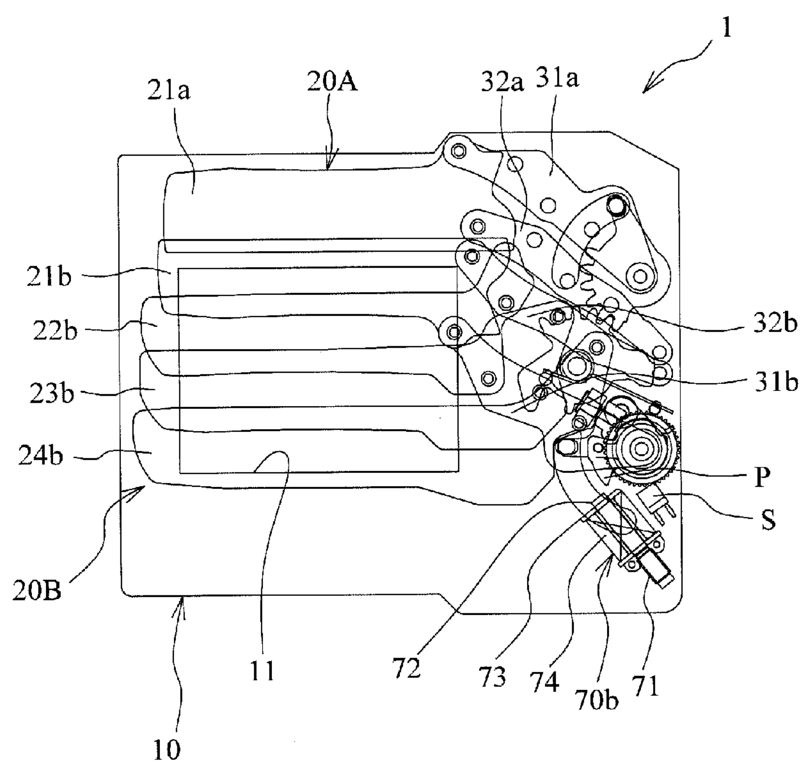
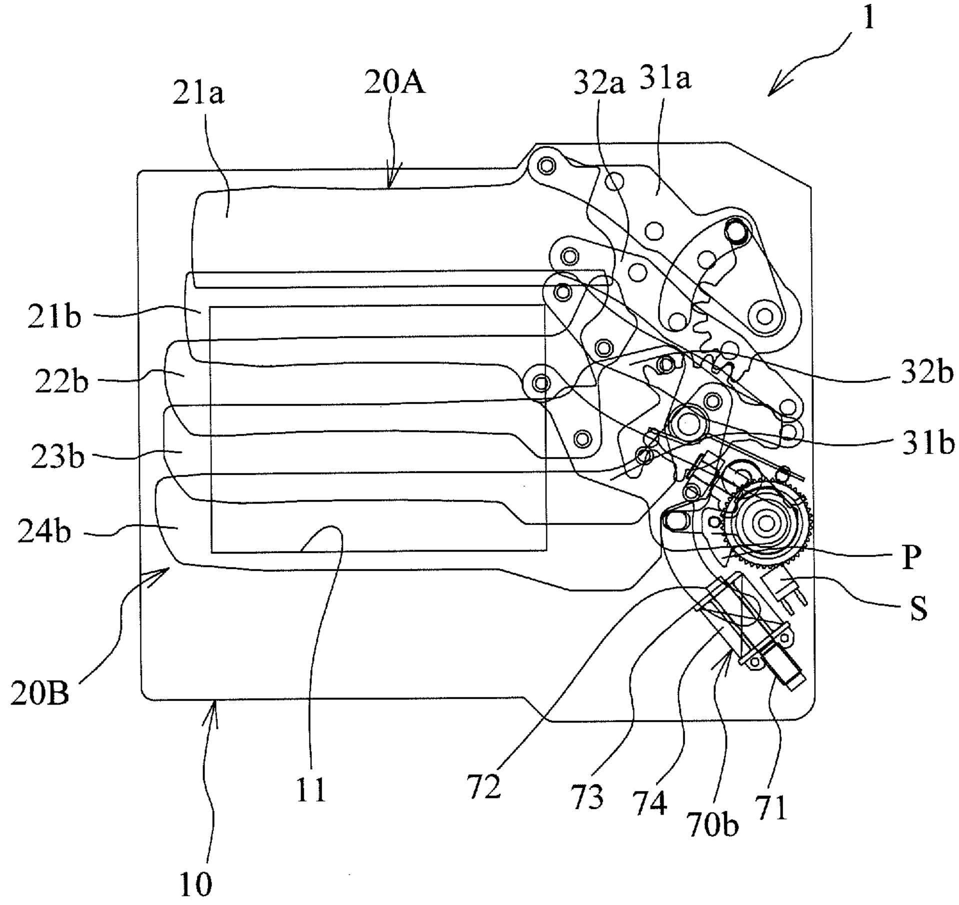


FIG. 1


1
21a
20A
32a
31a
21b
22b
23b
24b
32b
31b
P
S
20B
11
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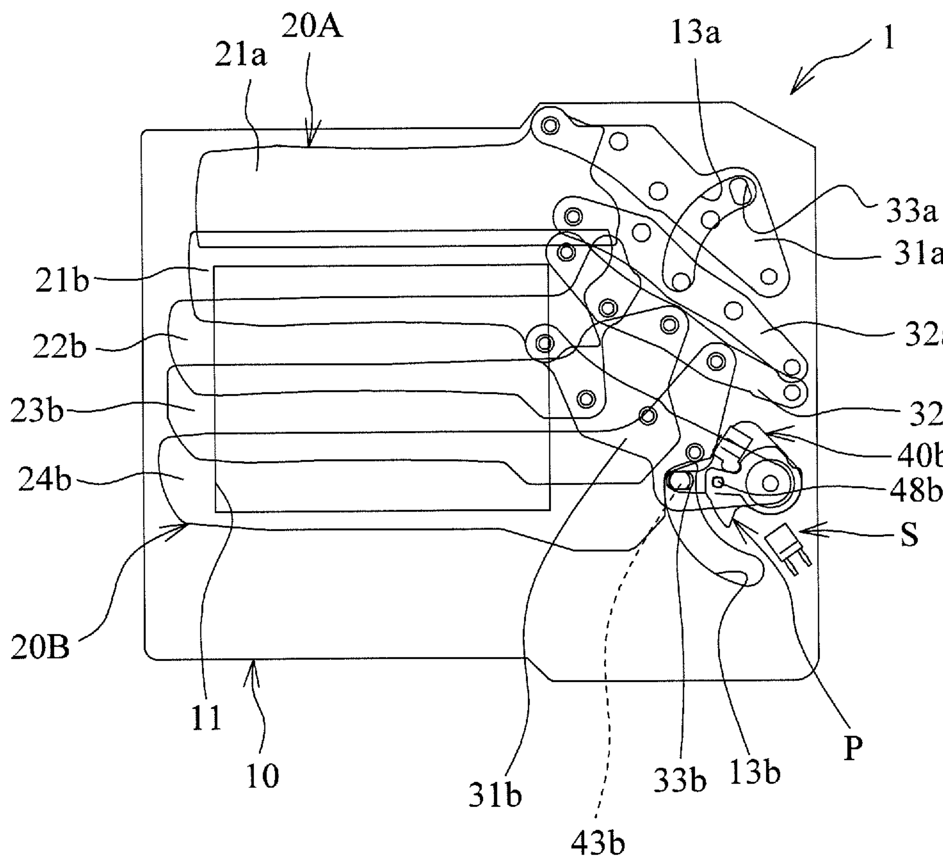
73
74
70b
71
10

FIG. 2



20A
21a
13a
1
33a
31a
21b
22b
32a
23b
32b
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24b
48b
S
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13b
P
43b

FIG. 3

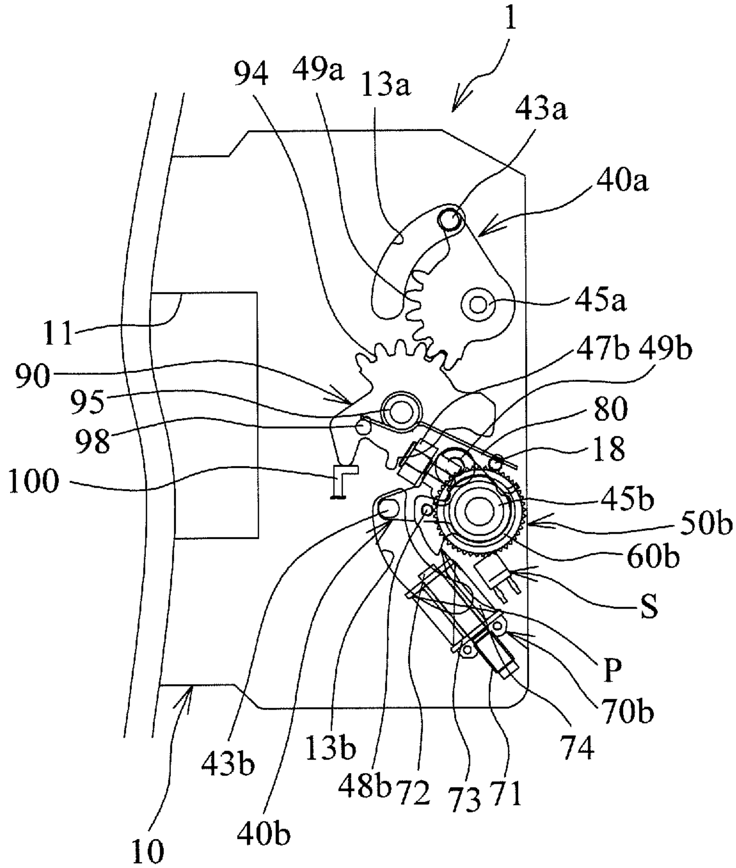

1
94
49a
13a
43a
40a
45a
11
47b
49b
90
95
80
98
18
100
45b
50b
60b
S
P
70b
74
43b
13b
48b
72
73
71
10
40b

FIG. 4A

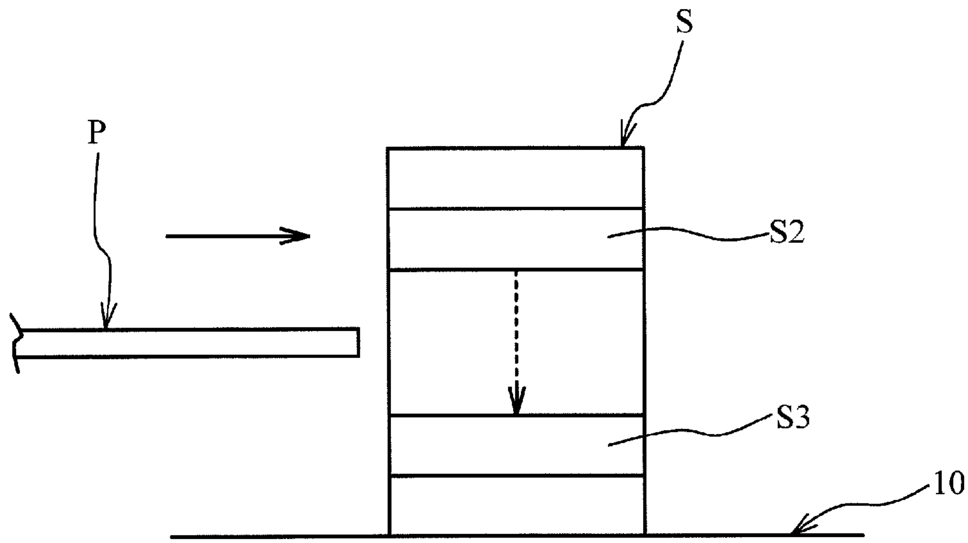


FIG. 4B

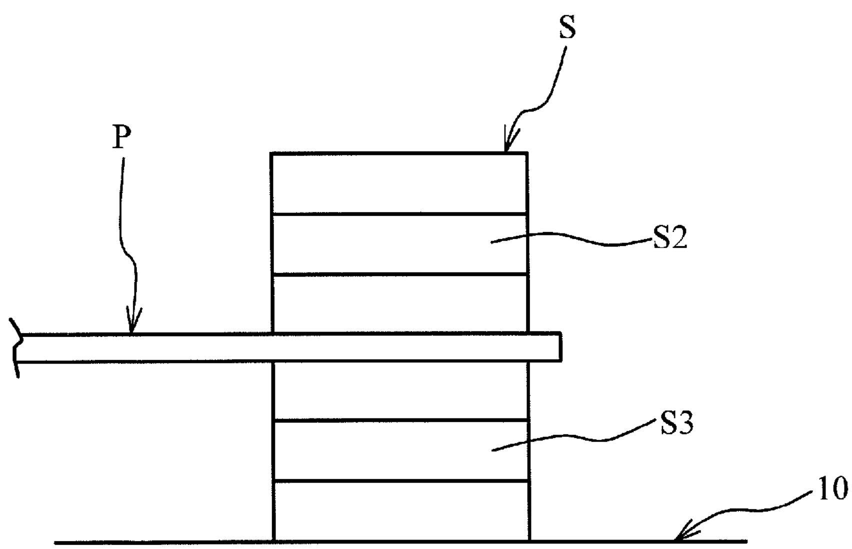


FIG. 5

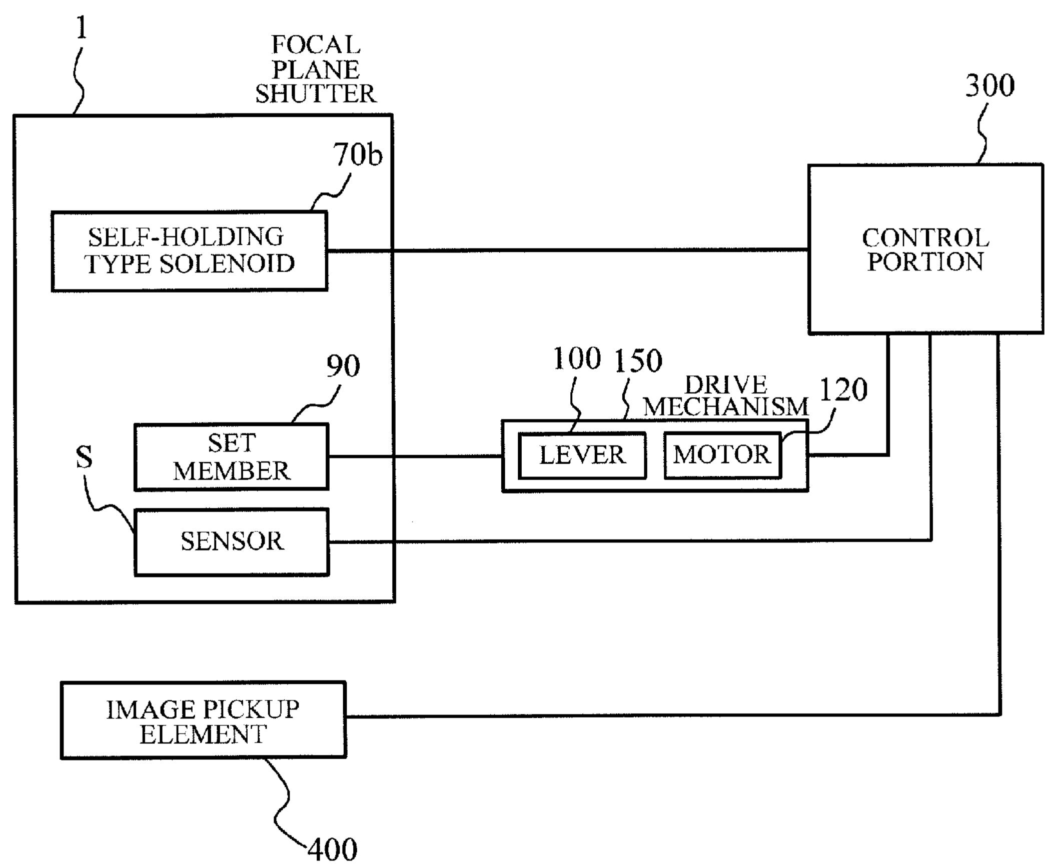

1
FOCAL PLANE SHUTTER
70b
SELF-HOLDING TYPE SOLENOID
90
SET MEMBER
S
SENSOR
100
150
DRIVE MECHANISM
120
LEVER
MOTOR
300
CONTROL PORTION
IMAGE PICKUP ELEMENT
400

FIG. 6

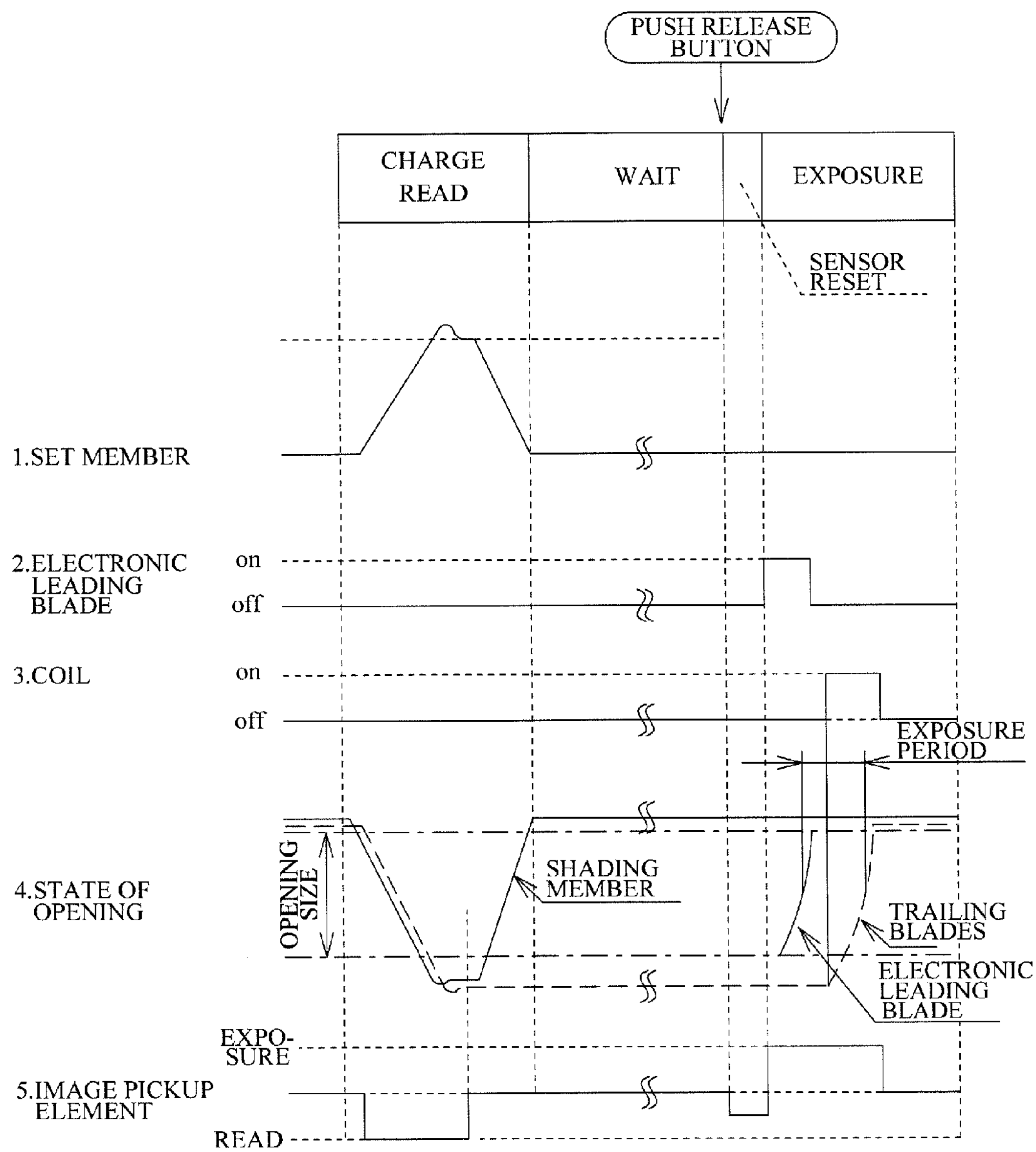

PUSH RELEASE BUTTON
CHARGE READ
WAIT
EXPOSURE
SENSOR RESET
1.SET MEMBER
2.ELECTRONIC LEADING BLADE
on
off
3.COIL
on
off
EXPOSURE PERIOD
4.STATE OF OPENING
OPENING SIZE
SHADING MEMBER
TRAILING BLADES
ELECTRONIC LEADING BLADE
EXPO-SURE
5.IMAGE PICKUP ELEMENT
READ

FIG. 7

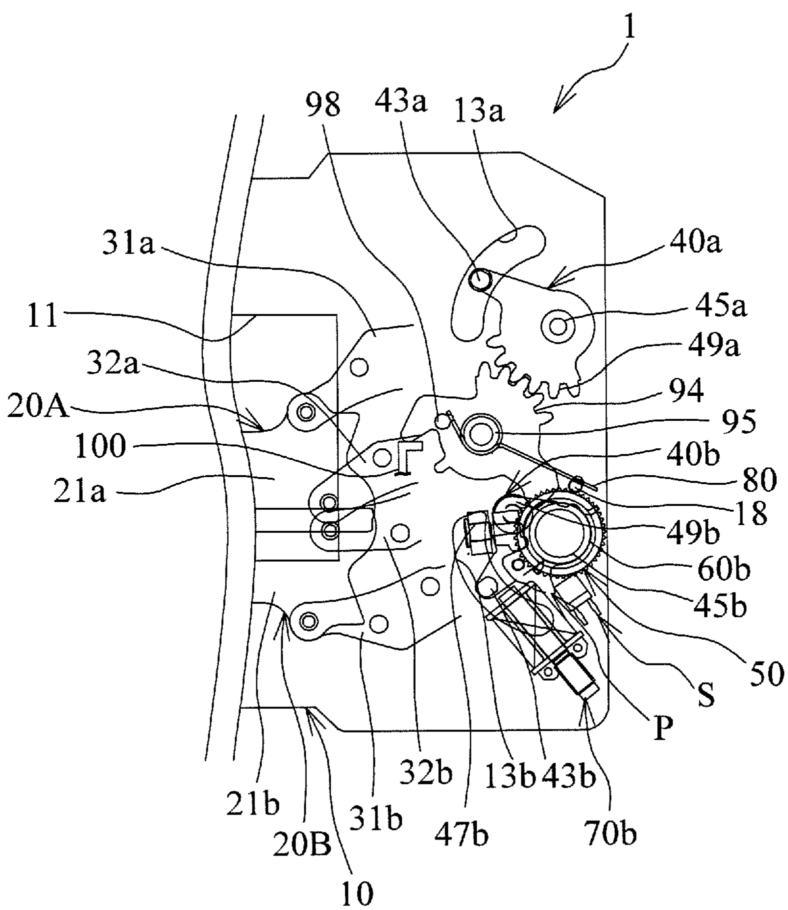
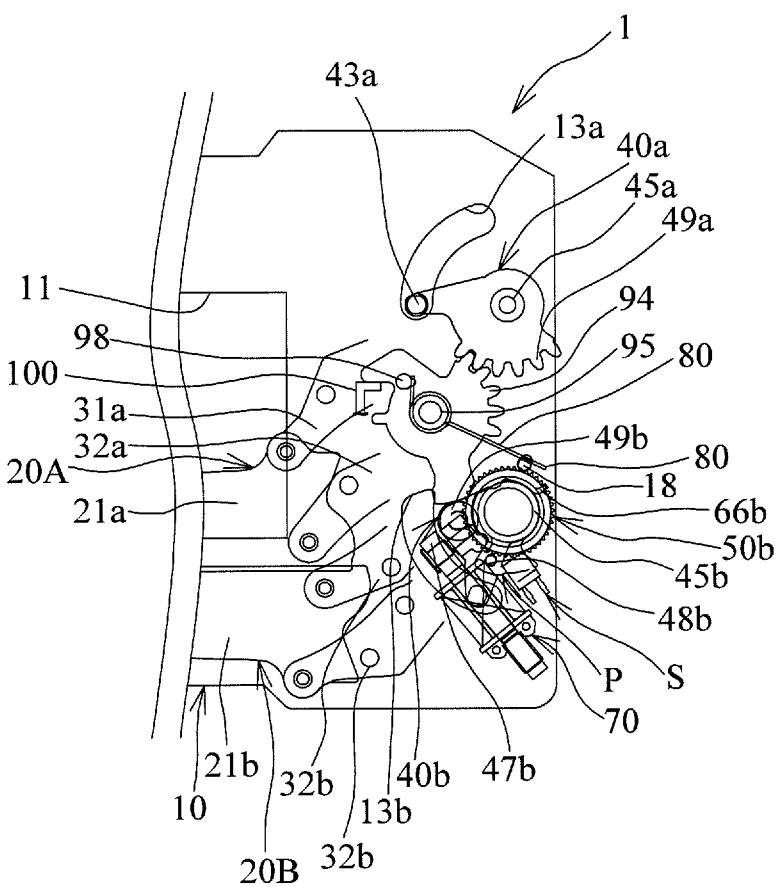

1
98
43a
13a
31a
40a
45a
11
49a
32a
94
20A
95
100
40b
80
21a
18
49b
60b
45b
50
S
P
21b
20B
10
31b
32b
13b
43b
47b
70b

FIG. 8


1
43a
13a
40a
45a
49a
11
94
98
95
80
100
31a
49b
32a
80
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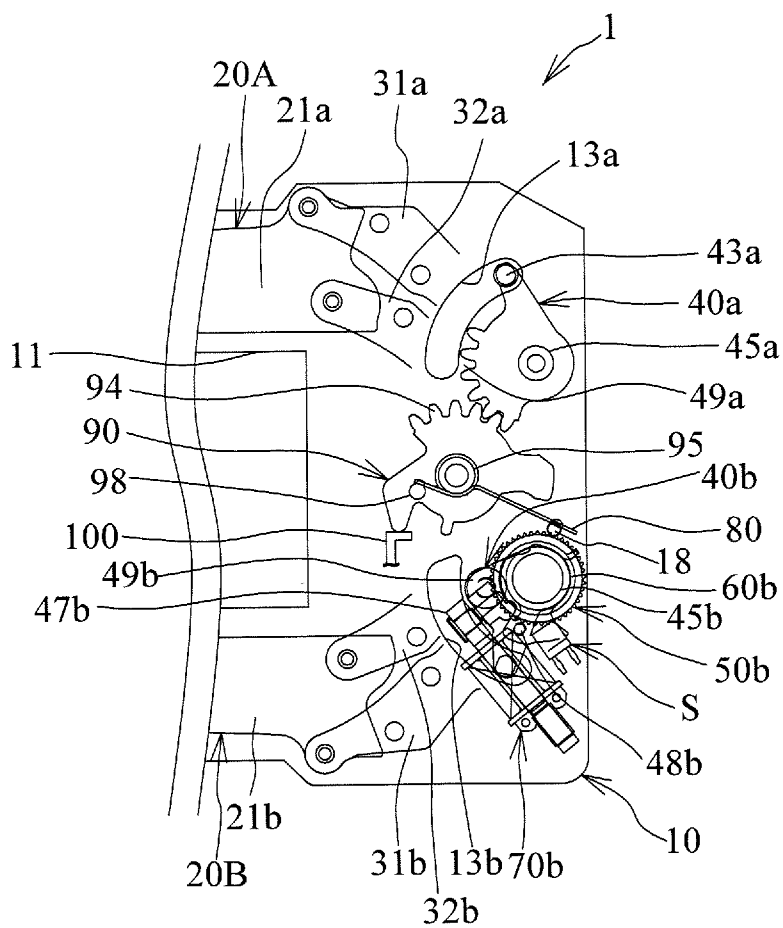
18
21a
66b
50b
45b
48b
P
S
70
21b
32b
40b
47b
10
13b
20B
32b

FIG. 9


1
20A
21a
31a
32a
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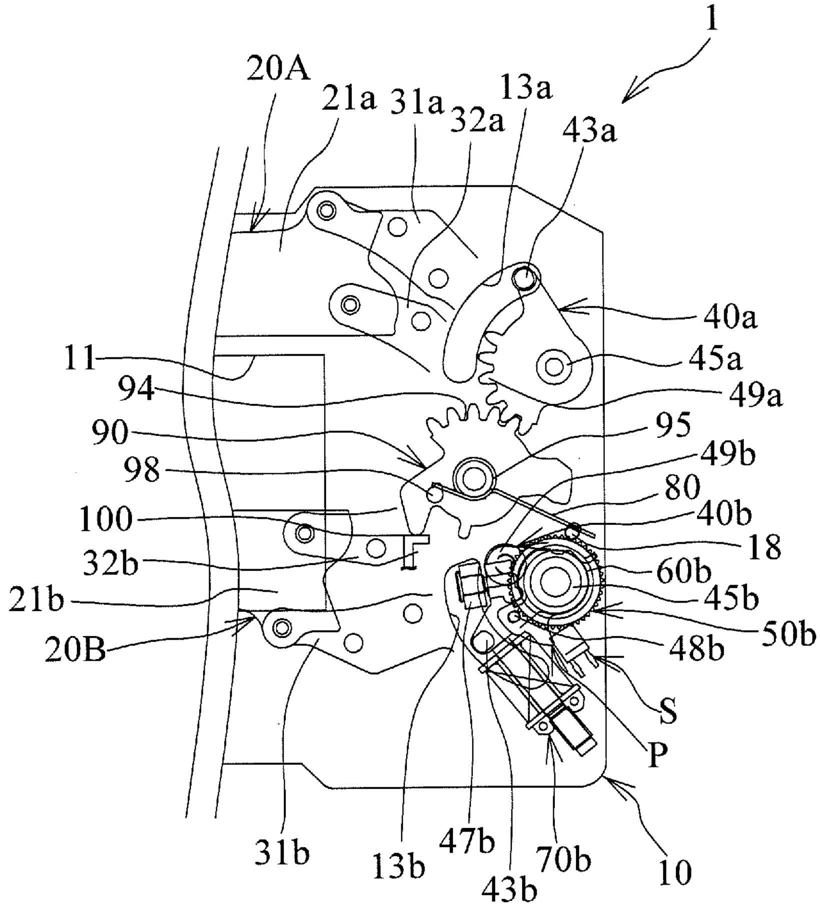
43a
40a
45a
11
94
49a
90
95
98
40b
100
80
18
49b
60b
47b
45b
50b
S
48b
10
21b
20B
31b
13b
70b
32b

FIG. 10


1
20A
21a
31a
32a
13a
43a
40a
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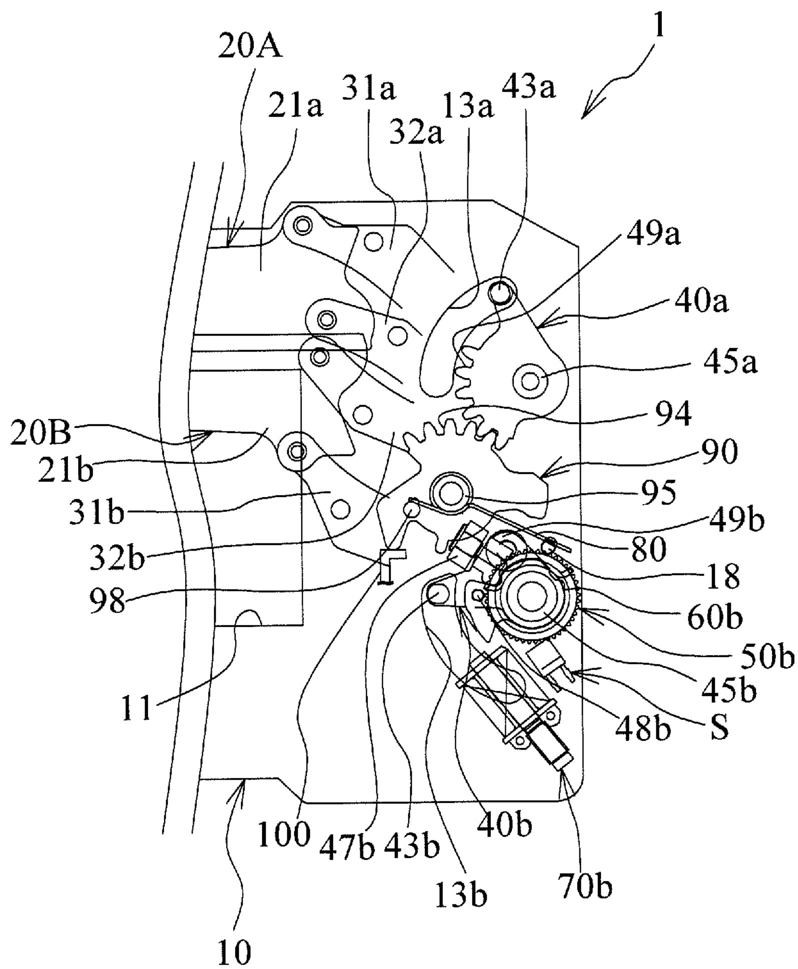
11
94
49a
90
95
98
49b
80
100
40b
32b
18
60b
21b
45b
50b
20B
48b
S
P
31b
13b
47b
43b
70b
10

FIG. 11


1
20A
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45a
94
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80
18
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50b
45b
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43b
13b
40b
70b
10

FIG. 12

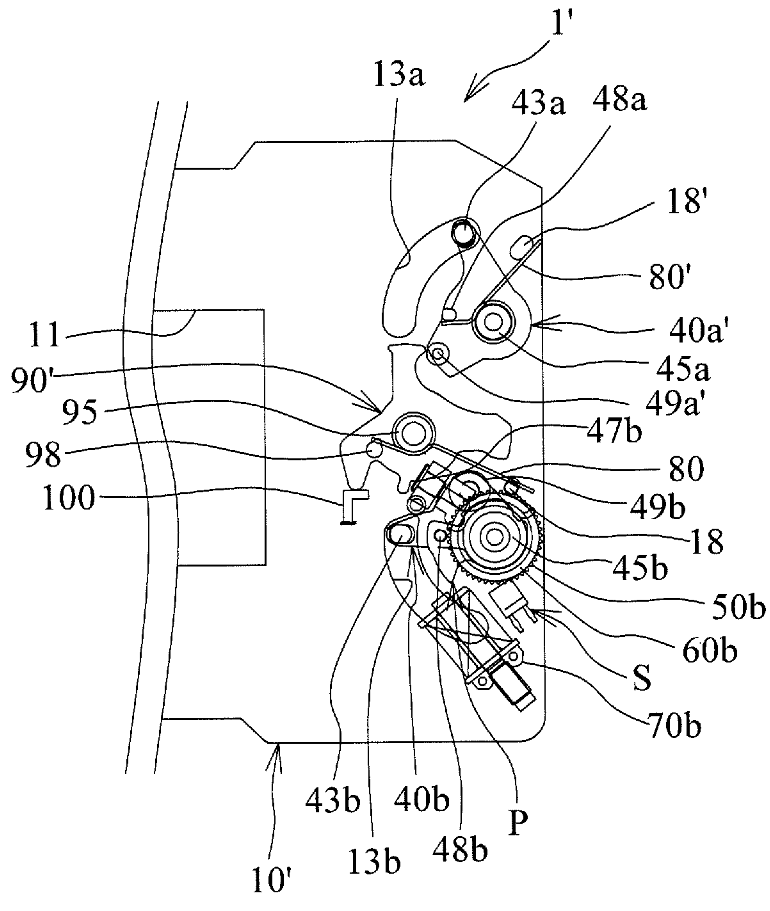
1'
13a
43a
48a
18'
80'
11
40a'
45a
90'
95
49a'
47b
98
80
100
49b
18
45b
50b
60b
S
70b
43b
40b
P
13b
48b
10'

IMAGE PICKUP DEVICE AND FOCAL PLANE SHUTTER

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims priority to Japanese Patent Application No. 2013-055576 filed on Mar. 18, 2013, the subject matter of this patent document is incorporated by reference herein in its entirety.

BACKGROUND

(i) Technical Field

The present invention relates to image pickup devices and focal plane shutters.

(ii) Related Art

For example, Japanese Patent Unexamined Application Publication No. 2010-34818 discloses an image pickup device with an electronic leading blade and mechanical trailing blades. After the electronic leading blade moves in the state where the trailing blades recede from an opening of a board, the trailing blades close the opening to perform exposure.

After an exposure operation is finished, image data are read from an image pickup element. During reading of the image data, the light has to be prevented from entering the image pickup element in consideration of an influence on the image data. Thus, the state where the opening is closed by the trailing blades has to be maintained for a predetermined period after the exposure operation.

In a case of using a normally open type shutter, the reading of the image date from the image pickup element is finished after the exposure operation, and then the trailing blades recede from the opening. This makes it possible to display a live view image on a liquid crystal display of a camera from the image pickup element in a real time manner, after the exposure operation.

Further, in continuous shooting, the reading of the image date from the image pickup element is finished after the exposure operation is finished, and then the trailing blades have to move away from the opening to perform a charging operation for a next exposure operation.

The trailing blades cannot be driven, until the image data are read from the image pickup element after the exposure operation. Thus, a shooting interval might not be shortened.

SUMMARY

It is therefore an object to provide an image pickup device and a focal plane shutter capable of shortening a shooting interval in using an electric leading blade.

According to an aspect of the present invention, there is provided an image pickup device including: an image pickup element; a control portion sequentially resetting charge stored in the image pickup element for every pixel line in a predetermined direction such that an electronic leading blade moves in a simulated manner; and a focal plane shutter including: a board including an opening for exposing the image pickup element; trailing blades being mechanical types and opening and closing the opening; a trailing-blade drive lever driving the trailing blades; an electromagnet capable of adsorbing and holding the trailing-blade drive lever; a biasing member biasing the trailing-blade drive lever to move away from the electromagnet; a set member moving the trailing-blade drive lever to abut the trailing-blade drive lever with the electromagnet such that the trailing blades move away from

the opening; a shading member opening and closing the opening; and a shading-member drive lever driving the shading member in response to the set member, wherein the shading member moves toward the opening to maintain a closed state of the opening in cooperation with the trailing blades, when the trailing blades are moved away from the opening by the set member, and the control portion reads image data from the image pickup element in the closed state.

According to another aspect of the present invention, there is provided a focal plane shutter including: a board including an opening; trailing blades being mechanical types and opening and closing the opening; a trailing-blade drive lever driving the trailing blades; an electromagnet capable of adsorbing and holding the trailing-blade drive lever; a biasing member biasing the trailing-blade drive lever to move away from the electromagnet; a set member moving the trailing-blade drive lever to abut the trailing-blade drive lever with the electromagnet such that the trailing blades move away from the opening; a shading member opening and closing the opening; and a shading-member drive lever driving the shading member in response to the set member, wherein the shading member moves toward the opening to maintain a closed state of the opening in cooperation with the trailing blades, when the trailing blades are moved away from the opening by the set member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view of a focal plane shutter according to a present embodiment;

FIG. **2** is a front view of a part of the focal plane shutter;

FIG. **3** is a front view of a part of the focal plane shutter;

FIGS. **4**A and **4**B are explanatory views of a sensor;

FIG. **5** is a block diagram of a camera equipped with the focal plane shutter;

FIG. **6** is a timing chart of the focal plane shutter;

FIG. **7** is an explanatory view of an operation of the focal plane shutter;

FIG. **8** is an explanatory view of the operation of the focal plane shutter;

FIG. **9** is an explanatory view of the operation of the focal plane shutter;

FIG. **10** is an explanatory view of the operation of the focal plane shutter;

FIG. **11** is an explanatory view of the operation of the focal plane shutter; and

FIG. **12** is an explanatory view of a variation of a focal plane shutter.

DETAILED DESCRIPTION

In the following, the present embodiment according to the present invention will be described with reference to the drawings. FIG. **1** is a front view of a focal plane shutter **1** according to the present embodiment. FIGS. **2** and **3** are front views of a part of the focal plane shutter. Additionally, reference numerals are given to some of the parts in FIGS. **1** to **3**.

As illustrated in FIG. **1**, the focal plane shutter **1** includes a board **10**, blades **21**_a_, **21**_b_ to **24**_b_, arms **31**_a_, **32**_a_, **31**_b_, and **32**_b_, and a self-holding type solenoid **70**_b_. The board **10** is formed of a resin. The board **10** is provided with a rectangular opening **11**.

Trailing blades **20**B include four blades **21**_b_ to **24**_b_. Also, a shading member **20**A includes four blades. However, only one blade **21**_a_ is illustrated in FIGS. **1** and **2**. FIGS. **1** to **3** illustrate the shading member **20**A in an overlapped state and the trailing blades **20**B in an expanded state. In FIGS. **1** to **3**, the shading member **20**A recedes from the opening **11** and the trailing blades **20**B close the opening **11**.

As illustrated in FIG. **2**, the shading member **20**A is connected to the arms **31***a* and **32***a*. The trailing blades **20**B are connected to the arms **31***b* and **32***b*. Each of the arms **31***a*, **32***a*, **31***b*, and **32***b* is swingably supported by the board **10**. The arms **31***a* and **31***b* are respectively provided with fitting holes **33***a* and **33***b*.

As illustrated in FIG. **3**, the board **10** is provided with a shading-member drive lever **40***a* (hereinafter, referred to as drive lever) and a trailing-blade drive lever **40***b* (hereinafter, referred to as drive lever) that drive the arms **31***a* and **31***b*, respectively. The drive levers **40***a* and **40***b* are respectively provided with spindles **45***a* and **45***b*. The spindles **45***a* and **45***b* are rotatably supported by the board **10**. Thus, each of the drive levers **40***a* and **40***b* is swingably supported in a given range by the board **10**. The drive levers **40***a* and **40***b* are respectively provided with drive pins **43***a* and **43***b*. The board **10** is provided with escape holes **13***a* and **13***b* that escape the movements of the drive pins **43***a* and **43***b*, respectively. Each of the escape holes **13***a* and **13***b* has an arc shape. The drive pins **43***a* and **43***b* are respectively fitted into the fitting hole **33***a* of the arm **31***a* and the fitting hole **33***b* of the arm **31***b*. Swinging the drive lever **40***a* causes the arm **31***a* to swing and to move the shading member **20**A. Likewise, swinging the drive lever **40***b* causes the arm **31***b* to swing and to move the trailing blades **20**B.

The drive lever **40***b* holds a movable iron piece **47***b*. The drive lever **40***b* is swingable from a position where the movable iron piece **47***b* abuts the self-holding type solenoid **70***b* to a position where the movable iron piece **47***b* recedes from the self-holding type solenoid **70***b*. The spindle **45***b* is fitted with a bias spring **60***b* having a coil shape. The bias spring **60***b* biases the drive lever **40***b* in such a direction that the movable iron piece **47***b* moves away from the self-holding type solenoid **70***b*.

The spindle **45***b* engages a ratchet gear **50***b*. The ratchet gear **50***b* engages one end of the bias spring **60***b*. The other end of the bias spring **60***b* engages the drive lever **40***b*. The rotational degree of the ratchet gear **50***b* is adjusted, so that the biasing force of the bias spring **60***b* can be adjusted.

The self-holding type solenoid **70***b* is capable of adsorbing to the movable iron piece **47***b* by a given attraction force in a non-energized state, and reduces the attraction force in an energized state. The self-holding type solenoid **70***b* includes: a yoke **72**; a coil bobbin **73** attached to the yoke **72**; a coil **74** wounded around the coil bobbin **73**; and a permanent magnet **71** secured to the yoke **72**. Since the permanent magnet **71** is provided in the yoke **72**, the yoke **72** also functions as a magnet. Therefore, the self-holding type solenoid **70***b* is capable of adsorbing to the movable iron piece **47***b* in the non-energized state.

Further, the coil **74** is energized to cancel a polarity generated in the yoke **72** by the permanent magnet **71**, thereby reducing the magnetic attraction force effecting between the yoke **72** and the movable iron piece **47***b*. Thus, the coil **74** is energized to cancel the polarity generated in the yoke **72** by the permanent magnet **71** while the movable iron piece **47***b* is abutting the yoke **72** of the self-holding type solenoid **70***b*, thereby reducing the magnetic attraction force between the yoke **72** and the movable iron piece **47***b*. Therefore, the drive lever **40***b* is swung by the biasing force of the bias spring **60***b*. In such a way, the movable iron piece **47***b* moves away from the self-holding type solenoid **70***b* after being adsorbed thereto. The self-holding type solenoid **70***b* is an example of an electromagnet.

Additionally, a typical electromagnet may be used instead of the self-holding type solenoid **70***b*. The electromagnet includes: a yoke; a coil bobbin assembled into the yoke; and a coil wound around the coil bobbin. The energization of the coil excites the yoke, and then the magnetic attraction force is generated between the yoke and the movable iron piece **47***b*. This maintains the drive lever **40***b* at a predetermined position. The energization of the electromagnet is stopped to swing the drive lever **40***b* in accordance with the biasing force of the bias spring **60***b*.

A set member **90** is provided for positioning the drive lever **40***b* at desirable positions. The set member **90** has a spindle **95** rotatably supported by the board **10**. The set member **90** is attached with a return spring **80** for returning the set member **90** to an initial position. The return spring **80** is fitted onto the spindle **95**. One end of the return spring **80** abuts a projection portion **18** formed in the board **10**. The other end of the return spring **80** abuts a projection portion **98** formed in the set member **90**. The return spring **80** biases the set member **90** counterclockwise.

A gear portion **94** is partly formed at an outer circumferential portion of the set member **90**. Also, a gear portion **49***a* is partly formed at an outer circumferential portion of the drive lever **40***a*. The gear portion **94** of the set member **90** and the gear portion **49***a* of the drive lever **40***a* mesh each other, thereby interlocking the drive lever **40***a* with the set member **90**. That is, the set member **90** and the drive lever **40***a* always drive together.

A thin plate P is arranged coaxially with the drive lever **40***b*. The thin plate P has a thin plate shape. An engagement pin **48***b* is formed in the drive lever **40***b* and fitted into the thin plate P. Therefore, the thin plate P and the drive lever **40***b* swing together. Further, a sensor S is arranged near the drive lever **40***b*. The sensor S is a sensor capable of detecting a position of the thin plate P. The sensor S detects the position of the thin plate P to detect a position of the trailing blades **20**B.

FIGS. **4**A and **4**B are explanatory views of the sensor S. The sensor S is arranged on the board **10**. The sensor S has a light emitting element S**2** and a light receiving element S**3** that are arranged to face each other. The light receiving element S**3** receives the light emitted from the light emitting element S**2**. As illustrated in FIGS. **4**A and **4**B, the thin plate P moves to be positioned between the light emitting element S**2** and the light receiving element S**3** in response to the swinging of the drive lever **40***b*. When being positioned between the light emitting element S**2** and the light receiving element S**3**, the thin plate P interrupts the light emitted from the light emitting element S**2**. At this time, whether or not the thin plate P is positioned between the light emitting element S**2** and the light receiving element S**3** can be detected based on output signals from the light receiving element S**3**, thereby detecting the position of the drive lever **40***b*. This can result in detecting the position of the trailing blades **20**B.

Additionally, the sensor S is not limited to the above configuration. For example, the sensor S may include: a light emitting element; a mirror reflecting the light emitted from the light emitting element; and a light receiving element receiving the light reflected by the mirror. The thin plate P is positioned between the light emitting element and the mirror, or between the light receiving element and the mirror, thereby detecting the position of the thin plate P.

A description will be given of a configuration of a camera equipped with the focal plane shutter **1**. FIG. **5** is a block diagram of the camera equipped with the focal plane shutter **1**. The camera includes: the focal plane shutter **1**; a drive mechanism **150**; a control portion **300**; and an image pickup element **400**. The control portion **300** controls an operation of the whole camera and includes a CPU, a ROM, and a RAM. Additionally, the camera includes lenses, not illustrated, for adjusting a focal length.

The control portion **300** controls an energization state of the coil **74** of the self-holding type solenoid **70***b*. The image pickup element **400** changes an object image into electric signals to generate image data. The control portion **300** reads and stores the generated image data in the image pickup element **400**. The image pickup element **400** is, for example, a CCD or a CMOS. The drive mechanism **150** drives the set member **90** in response to the instruction from the control portion **300**. The control portion **300** controls the energization of the coil **74** of the self-holding type solenoid **70***b* based on output signals from the sensor S, as will be described later.

The drive mechanism **150** includes: a lever **100** driving the set member **90**; and a motor **120** capable of linearly reciprocating the lever **100** by a known technique, and rotatable in forward and reverse directions. The motor **120** is a stepping motor, and drives the lever **100** via gears not illustrated. The control portion **300** controls the driving of the motor **120** to control the lever **100**. This controls the rotation of the set member **90**. The control portion **300** controls the rotational speed of the motor **120** to control the driving speed of the lever **100**. This controls the rotational speed of the set member **90**.

The control portion **300** corresponding to an example of a control portion sequentially resetting charge stored in the image pickup element **400** for every pixel line in a predetermined direction such that an electronic leading blade moves in a simulated manner. Specifically, the charge stored in the image pickup element **400** is reset for every pixel line in the direction perpendicular to the direction in which the trailing blades **20**B move. Therefore, the electronic leading blade artificially moves from an exposure start position to an exposure end position. Also, the image pickup element **400** is exposed from the opening **11**, when the shading member **20**A and the trailing blades **20**B recede from the opening **11**.

Additionally, a mode is changed into a single shooting mode or a continuous shooting mode, as depending on the operation to the release button of the camera. The mode is changed to the continuous shooting mode by long pushing the release button, and the camera shoots continuously while the release button is pushed. The mode is changed to the single shooting mode by short pushing the release button, and the camera shoots an image whenever the release button is pushed.

Next, an operation of the focal plane shutter **1** will be described. FIG. **6** is a timing chart of the focal plane shutter **1**. FIGS. **7** to **11** are explanatory views of the operation of the focal plane shutter **1**. Additionally, some parts are omitted in FIGS. **7** to **11**. Additionally, some reference numerals are omitted in FIGS. **7** to **11**. FIGS. **1** to **3** illustrate a state just after an exposure operation is finished.

After the exposure operation illustrated in FIGS. **1** to **3** is finished, a charging operation is started. Specifically, the set member **90** is rotated clockwise against the biasing force of the return spring **80** by driving the lever **100** illustrated in FIG. **3**. Since the gear portion **94** of the set member **90** meshes the gear portion **49***a* of the drive lever **40***a*, the drive lever **40***a* swings counterclockwise. Also, the set member **90** abuts a roller **49***b* provided in the drive lever **40***b* and causes the drive lever **40***b* to swing counterclockwise. Therefore, the shading member **20**A expands and moves to close the opening **11**. The trailing blades **20**B move away from the opening **11**. Therefore, the trailing blades **20**B are positioned at a movement start position. Here, during the charging operation, the shading member **20**A and the trailing blades **20**B move to maintain a closed state of the opening **11**. In particular, the shading member **20**A moves toward the opening **11** to follow the trailing blades **20**B moving away from the opening **11**. Thus, while the trailing blades **20**B is moving away from the opening **11**, the shading member **20**A moves toward the opening **11** to maintain the closed state of the opening **11**. It will be described later in detail. Additionally, when the drive lever **40***b* swings counterclockwise, the thin plate P also swings counterclockwise.

The swinging of the thin plate P counterclockwise allows the sensor S to detect the thin plate P. FIG. **7** illustrates the focal plane shutter **1** in a state where the sensor S starts detecting the thin plate P. Before the trailing blades **20**B fully recede from the opening **11** and before the movable iron piece **47***b* abuts the self-holding type solenoid **70***b*, the sensor S detects the thin plate P.

Further, when the set member **90** rotates clockwise, the drive levers **40***a* and **40***b* further swing counterclockwise. As illustrated in FIG. **8**, the shading member **20**A closes the opening **11**, and the trailing blades **20**B recede from the opening **11**. In this state, the movable iron piece **47***b* abuts the self-holding type solenoid **70***b*.

After that, the control portion **300** causes the lever **100** to move away from the set member **90**. Therefore, the set member **90** swings counterclockwise in accordance with the biasing force of the return spring **80**. Since the drive lever **40***a* meshes the set member **90**, the drive lever **40***a* swings clockwise and the shading member **20**A moves away from the opening **11**. Further, the movable iron piece **47***b* of the drive lever **40***b* is maintained in the state of being adsorbed to and held by the yoke **72** of the self-holding type solenoid **70***b*. Thus, the trailing blades **20**B also is maintained in the state of receding from the opening **11**. Thus, as illustrated in FIG. **9**, the shading member **20**A and the trailing blades **20**B recede from the opening **11**, so the opening **11** is brought into the opened state. The focal plane shutter **1** is brought into a wait state illustrated in the timing chart of FIG. **6**. In addition, in the wait state, the self-holding type solenoid **70***b* is not energized. Further, since the shading member **20**A and the trailing blades **20**B recede from the opening **11** in the wait state, it is possible to perform the live view display in which output from the image pickup element **400** is displayed on a liquid crystal monitor of the camera in a real time manner.

Subsequently, in shooting, a release button of the camera is pushed, the control portion **300** performs a sensor reset to erase the charges stored in the image pickup element **400**. Next, the control portion **300** controls the image pickup element **400** to move the electronic leading blade from the exposure start position to the exposure end position in a simulated manner. After a predetermined period lapses since the electronic leading blade starts moving, the control portion **300** energizes the coil **74** of the self-holding type solenoid **70***b*. This reduces the magnetic attraction force effecting between the self-holding type solenoid **70***b* and the movable iron piece **47***b*, and then the drive lever **40***b* is rotated clockwise by the biasing force of the bias spring **60***b*. Thus, the trailing blades **20**B move to close the opening **11** as illustrated in FIG. **10**. FIG. **11** illustrates the state just after the exposure operation is finished. The state illustrated in FIG. **11** is the same as the states illustrated in FIGS. **1** to **3**. In such a way, one cycle of shooting is finished. The energization of the coil **74** of the self-holding type solenoid **70***b* is stopped after a given period lapses since the energization starts. Additionally, the drive lever **40***b* swings counterclockwise, and then the thin plate P recedes from the sensor S to change its output value. The fully opened state of the opening **11** as illustrated in FIG. **9** is formed not only in photo shooting but also in movie shooting.

After the exposure operation is finished, the charging operation is performed by maintaining the state, illustrated in FIGS. **7** and **8**, in which the trailing blades **20**B recede from the opening **11**, again. Also, the shading member **20**A moves away from the opening **11** in the state where the trailing blades **20**B recede from the opening **11**.

In the continuous shooting mode, after a predetermined period lapses since the charging operation is finished, the sensor reset is performed to erase the charges stored in the image pickup element **400**, and the exposure is performed again. A waiting period in the continuous shooting mode is set longer than a period needed for stopping of the bound of the shading member **20**A at the time when the shading member **20**A moves away from the opening **11** and stops. In the single shooting mode, the real-time images are displayed on the liquid crystal monitor of the camera in a wait state after the charging operation.

Here, in the charging operation, while the trailing blades **20**B are moving away from the opening **11**, the shading member **20**A moves toward the opening **11** to maintain the closed state of the opening **11** in cooperation with the trailing blades **20**B, as mentioned above. While the shading member **20**A and the trailing blades **20**B cooperatively close the opening **11** in the charging operation, the control portion **300** reads the image data from the image pickup element **400**. In such a way, the image data of the image pickup element **400** are read in the charging operation in the present embodiment.

Thus, a period needed for shooting an image can be shortened, as compared with a case where the charging operation is performed after the reading of the image date from the image pickup element **400** is finished. Therefore, high-speed continuous shooting can be achieved in the continuous shooting mode. Also, a period needed for shooting an image can be shortened even in the single shooting mode, thereby shortening a shooting interval.

Additionally, the image data are read from the image pickup element **400** in the closed state of the opening **11** in the embodiment, so the smear or the like can be prevented. Also, the reading of the image data may start, before the trailing blades **20**B start moving away from the opening **11** after the exposure operation is finished. The reading of the image data has only to be finished in the state where the trailing blades **20**B close the opening **11** and before the shading member **20**A starts moving away from the opening **11**.

The focal plane shutter **1** is not provided with an electromagnet for holding the drive lever **40***a* at a predetermined position. Thus, as for the focal plane shutter **1**, the number of the parts is reduced, so reduced size, reduced weight, and reduced cost are achieved. Also, there is no electromagnet for holding the drive lever **40***a* at a predetermined position, thereby suppressing the power consumption.

The self-holding type solenoid **70***b* is a solenoid of a self holding type capable of adsorbing and holding the drive lever **40***b* in the non-energization state. Thus, as illustrated in FIG. **6**, the coil **74** of the self-holding type solenoid **70***b* is energized only when the drive lever **40***b* moves away from the self-holding type solenoid **70***b*. Thus, the energization period of the self-holding type solenoid **70***b* is so short to suppress the power consumption in the present embodiment, as compared with an electromagnet for adsorbing and holding the drive lever **40***b* by the enegization.

Additionally, in the state where the shading member **20**A recedes from the opening **11** as illustrated in FIG. **9**, the set member **90** is restricted from swinging clockwise by the return spring **80**. That is, in the state illustrated in FIG. **9**, when the clockwise force is exerted on the set member **90** for some reason, the biasing force of the return spring **80** acts to return the set member **90** back to the initial position. Here, the drive lever **40***a* meshes the set member **90**, so the biasing force of the return spring **80** acts to return the drive lever **40***a* to the initial position. For this reason, for example, when the shock is applied to the focal plane shutter **1**, the positional displacement of the drive lever **40***a* is prevented. Thus, it is prevented that the shading member **20**A is positionally displaced and is moved toward the opening **11** by the shock or the like.

Also, the drive lever **40***a* always meshes the set member **90**, and the set member **90** is biased by the return spring **80**. This provides the drive lever **40***a* side with no biasing member for biasing the drive lever **40***a* in one direction. Thus, the number of the parts is reduced.

The shading member **20**A does not drive at the time of the exposure operation. The exposure operation is performed by the electronic leading blade and the mechanical trailing blades **20**B. Thus, unlike mechanical leading blades, the movement property of the shading member **20**A, for example, such as a movement start timing, does not have to be strictly set.

The above embodiment has been described an example in which the set member **90** interlocks with the drive lever **40***a* by meshing the gear portion **94** of the set member **90** with the gear portion **49***a* of the drive lever **40***a*. However, the present invention is not limited to this. For example, the set member may interlock with the drive lever by a lever or the like.

Also, in the above embodiment, the set member **90** directly engages the drive lever **40***a*. However, the present invention is not limited to this. For example, the set member may interlock with the drive lever through another member such as a gear.

FIG. **12** is an explanatory view of a variation of a focal plane shutter **1'**. Additionally, the same components have the same reference numerals in order to avoid a duplicated explanation. Also, the configuration is partly omitted in FIG. **12**. There is no gear portion provided in a set member **90'** or a drive lever **40***a***'**. A return spring **80'** is wound around a spindle **45***a* of the drive lever **40***a***'**. One end of the return spring **80'** abuts a projection portion **18'** formed on a board **10'**. The other end of the return spring **80'** abuts a projection portion **48***a* formed on the drive lever **40***a***'**. The return spring **80'** biases the drive lever **40***a***'** clockwise. Also, a roller **49***a***'** is provided in the drive lever **40***a***'**.

When the set member **90'** swings clockwise in the state where the shading member **20**A recedes from the opening **11**, the set member **90'** pushes the roller **49***a***'** of the drive lever **40***a***'** to swing the drive lever **40***a***'** counterclockwise against the biasing force of the return spring **80'**. Therefore, the shading member **20**A moves toward the opening **11**. Also, when the set member **90'** swings counterclockwise in the state where the shading member **20**A closes the opening **11**, the roller **49***a***'** pushes the set member **90'** in accordance with the biasing force of the return spring **80'**, so that the drive lever **40***a***'** swings clockwise to follow the set member **90'**. Therefore, the shading member **20**A moves away from the opening **11**. In such a way, the drive lever **40***a***'** interlocks with the set member **90'**. A shooting interval can also be shortened in using the electronic leading blade by such a focal plane shutter **1'**.

The drive lever **40***a***'** is biased clockwise by the return spring **80'**. This can prevent the shading member **20**A from being positionally displaced and being moved toward the opening **11** due to the shock or the like.

The set member **90'** and the drive lever **40***a***'** do not always have to abut each other. For example, the set member **90'** may be spaced from the drive lever **40***a***'** in the state where the shading member **20**A recedes from the opening **11**. The set member **90'** may abut and swing the drive lever **40***a*', only when the set member **90'** swings the drive lever **40***b*.

While the exemplary embodiments of the present invention have been illustrated in detail, the present invention is not limited to the above-mentioned embodiments, and other embodiments, variations and modifications may be made without departing from the scope of the present invention.

The focal plane shutter according to the present embodiment can be employed in an optical apparatus such as a still camera or a digital camera.

Although the blade made of a synthetic resin has been described in the present embodiment, the blade having the thin shape may be made of a metal.

In the above embodiment, the shading member and the trailing blades are each composed of four blades. However, the shading member and the trailing blades are not limited to these arrangements. The shading member and the trailing blades may be each composed of two to five blades and may be different in number.

The sensor S detects the position of the drive lever **40***b* in response to the thin plate P interrupting the light emitted from the light emitting element S**2** toward the light receiving element S**3**. However, the sensor S is not limited to this configuration. For example, a sensor may be provided at a position such that the blade **21***b* interrupts the light emitted from the light emitting element S**2** toward the light receiving element S**3** in accordance with the traveling of the trailing blades **20**B.

What is claimed is:

1. An image pickup device, comprising:

an image pickup element;

a control portion sequentially resetting charge stored in the image pickup element for every pixel line in a predetermined direction such that an electronic leading blade moves in a simulated manner; and

a focal plane shutter including:

a board including an opening for exposing the image pickup element;

trailing blades being mechanical types and opening and closing the opening;

a trailing-blade drive lever driving the trailing blades;

an electromagnet capable of adsorbing and holding the trailing-blade drive lever;

a spring biasing the trailing-blade drive lever to move away from the electromagnet;

a set member moving the trailing-blade drive lever to abut the trailing-blade drive lever with the electromagnet such that the trailing blades move away from the opening, wherein the set member includes a spindle rotatably supported by the board, and wherein the set member rotates to move the trailing-blade drive lever;

a shading member opening and closing the opening, wherein the shading member includes a plurality of blades; and

a shading-member drive lever driving the shading member in response to the set member,

wherein the set member and the shading-member drive lever are always interlocked with each other,

wherein the shading member moves toward the opening to maintain a closed state of the opening in cooperation with the trailing blades, when the trailing blades are moved away from the opening by the set member, and

wherein the control portion reads image data from the image pickup element in the closed state.

2. The image pickup device of claim **1**, wherein the set member and the shading-member drive lever have gear portions meshing with each other.

3. The image pickup device of claim **1**, wherein the shading-member drive lever is biased to engage the set member.

4. The image pickup device of claim **1**, wherein the focal plane shutter is not provided with an electromagnet for holding the shading-member drive lever at a predetermined position.

5. The image pickup device of claim **1**, wherein the electromagnet is a self-holding type solenoid capable of adsorbing and holding the trailing blade-drive lever in a non-energized state.

6. A focal plane shutter, comprising:

a board including an opening;

trailing blades being mechanical types and opening and closing the opening;

a trailing-blade drive lever driving the trailing blades;

an electromagnet capable of adsorbing and holding the trailing-blade drive lever;

a spring biasing the trailing-blade drive lever to move away from the electromagnet;

a set member moving the trailing-blade drive lever to abut the trailing-blade drive lever with the electromagnet such that the trailing blades move away from the opening, wherein the set member includes a spindle rotatably supported by the board, and wherein the set member rotates to move the trailing-blade driver lever;

a shading member opening and closing the opening, wherein the shading member includes a plurality of blades; and

a shading-member drive lever driving the shading member in response to the set member,

wherein the set member and the shading-member drive lever are always interlocked with each other, and

wherein the shading member moves toward the opening to maintain a closed state of the opening in cooperation with the trailing blades, when the trailing blades are moved away from the opening by the set member.

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